Proceedings of the Iowa Academy of Science

Volume 13 | Annual Issue Article 5

1906

Presidential Address - A Review of the Development of Mineralogy

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PRESIDENTIAL ADDRESS

A REVIEW OF THE DEVELOPMENT OF MINERALOGY.

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Man's interest in and knowledge of some of the commoner minerals such as quartz, mica and calcite, the native metals and the precious stones, must have begun practically with the beginning of his occupancy of the earth and the command given to him to subdue the earth involved bringing its inorganic matters within the range of his knowledge and control. Thus early were the physical sciences authoritatively introduced into the curriculum of the great school of his life. The first note of progress is made early in Genesis in the mention of Tubal Cain as "an instructor of every artificer of brass and iron"; the gold, bdellium, whatever that may be, and the onyx stone are previously mentioned. The Pentateuch indicates a ready practical knowledge of a half dozen metals and as many more precious stones. Theophrastus, a Greek, who lived about three hundred years before Christ, has left the earliest specific writings upon minerals. The elder Pliny, with his wide embracing interest in every phase of natural history, did not neglect the minerals and made some interesting records of his observations upon them. Avicenna in the eleventh century, so far as is known, made the first attempt to classify minerals. His effort was necesarily crude and unsatisfactory. However, the number of minerals known and the knowledge of uses that could be made of them gradually increased thru the centuries. Among other causes the eager desire for gold, the belief that the baser might be transmuted into it, together with a universal hope that somehow a panacea for the ills of the body might be found, stimulated research and resulted in the acquirement of a working knowledge of the physical and chemical properties of many mineral substances.

There is little evidence that any well directed effort to make a systematic array of the facts and principles respecting inorganic substances had been made before the middle of the eighteenth century. The foundations of any science are well laid only after the tentative setting forth of a variety of theories, the earlier of which are crude often and in the light of later established principles, absurdly inadequate. So was it with mineralogy. Crystals by their natural beauty early attracted attention. At first the seemingly endless diversity of crystalline forms prevented the recognition of any connection between fixity of form and kind. Naturally the faces were considered in the first attempt to establish this fact and in consequence failure resulted. The inherent tendency of the mind to generalize and guess rather than to examine and measure, as Whewell expresses it, led to various assumptions, the prevalence of which were serious obstacles to the initiation of any attempt to arrive at better conclusions. Thus Pliny, Gessner, in the sixteenth century, Caesalpinus in the seventeenth and even Buffon in the eighteenth, denied the fixity of form of crystals. Nicholas Steno in 1669 published the statement that tho the sides of the hexagonal crystal may vary the angles are not changed. This dictum, tho not accepted by all, as we have seen, became the basis of much patient observation on the part of many. Linnaeus first attempted to make the crystalline form the basis for the arrangement of minerals in groups, but was not successful in his plan. However, Rome 'de Lisle, in reading the works of Linnaeus, found suggestions that led to his giving to the form of crystals his devoted study thru a wide range of application. By his efforts and those of Hauy a little later, crystallography was definitely founded as a means of determining minerals apart from chemistry. The part of Rome 'de Lisle seems to have been to prepare the way by patient industry in investigation of details for the establishment by Hauy of the principles of crystallography upon such a sure foundation that they have been recognized and employed ever since by all those who have continued the work. To him is given the credit of maintaining the importance of cleavage and the consequent explanation of the derivation of secondary from primary forms by means of the decrements of the successive layers of integral molecules; "the mathematical deduction of the dimensions and proportions of these secondary forms; the invention of a notation to express them; the examination of the whole mineral kingdom in accordance with these views; and the production of a work in which they are explained with singular clearness and vivacity." His industry and skill command the admiration of all who have become acquainted with the contributions which he has made to the evolution of crystallography. Some of his devices and deductions have been superseded by the results of later investigations, but even they served a valuable purpose in becoming the vehicles for the safe carriage of facts which were necessary to the successful determination of the better systems of those who could thus profit by the labors of this truly remarkable pioneer in mineralogy. It is true that he had the results of the labors of the painstaking and enthusiastic Rome 'de Lisle and others by which to profit, but his, nevertheless, is the unique virtue of having used them in such a manner as to have wrought them into a consistent and acceptable system that in its essential features continues in force up to the present time.

Later progress in crystallography has consisted largely in increasing the accuracy of angle measurements and in adding to our knowledge of derived forms. Wollaston made the first of these more readily possible by his invention of the reflecting goniometer by which the angles of very minute faces could be measured with great accuracy. Two other Englishmen, Phillips and Brooke, made diligent use of this instrument in securing exact measurements of the angles of a large number of minerals, the results of which were published for the benefit of students of the science.

To Weiss and Mohs chiefly is due the credit of making the Axes of Symmetry the bases for the arrangement of crystalline forms into systems, which arrangement has been confirmed by the other properties of minerals that received attention at about the same time. Sir David Brewster, in his optical researches, discovered that double refraction pertained solely to crystals of the rhombohedral system. Later he found that all crystals of the pyramidal and rhombohedral systems which from their geometrical character have a single axis of symmetry are optically uniaxial, while the prismatic system which has three unequal axes of symmetry is optically biaxial and has three rectangular axes of unequal elasticity. While Brewster's discoveries and conclusions were reached independently of Weiss and Mohs, they cover very much the same ground, tho' reached by a very different path, and support the conclusions of the last named investigators in a remarkable manner. Later investigations along both lines have resulted in establishing a very high degree of correspondence between mathematical and optical symmetry and have given to crystallography an assured place of first class importance in mineralogy.

Hauy had assumed that the same chemical elements, combined in the same proportion, would always have the same crystalline form, and, consequently, the same form and angles implied the same chemical constitution. But there were continually arising very perplexing exceptions to this view. Fuchs was led to account for this on the principle that one element might take the place of another in some instances without altering the crystalline form. To such elements he applied the term vicarious. He is said afterward to have withdrawn from his position in this matter. But Mitscherlich, by many careful analyses, clearly established the fact that several substances such as "the carbonates of lime, of magnesia, of protoxide of iron and of protoxide of manganese agree in many respects of form, while the homologous angles vary thru one or two degrees only". These and similar substances were said to be isomorphous, if the agreement was complete, or exact; while the term plesiomorphic was given to such as varied slightly. This discovery resulted in stimulating great activity among chemists and crystallographers in the expectation of discovering definite laws pertaining to the relation between chemical composition and crystalline form. One result of such effort was the recognition of cases that seem to be exceptional and outside of the usual laws governing mineral form and composition, such as dimorphism and trimorphism, an illustration of the former of which we have in calcite and aragonite.

It will be seen from the discussion of the development of crystallography that the establishment of any satisfactory system has depended upon the agreement of fixity of form and angle with kind. While Hauy and his followers were unfolding the principles of crystallography and placing them upon a sure basis, Abraham Werner was laboring to find in the fixity of the other properties of minerals as certain a basis for a different system of classification and determination. Possessed of exact and methodical mental powers and great acuteness of the senses, he was eminently adapted to the founding of such a system. In this work he relied mainly upon color, luster, hardness and specific gravity, all of which with practice are readily determinable, a very little apparatus of the simplest character being required. His success as a mineralogist attracted general attention at once and students from every part of Europe attended his lectures at Freiberg with the result that his method of employing external characters in the determination of minerals was promptly and widely disseminated. Mohs, his successor at Freiberg, improved Werner's standards and nomenclature, an illustration of which is found in the scale of hardness still in use with which the hardness of any mineral in question may be brought into comparison with ready exactness.

Every early investigator in mineralogy had felt the necessity for a complete system of classification and sought to discover some basis on which such a system could be devised. Thus chemistry, crystallography, and physical properties had been appealed to in turn for a key to some system by which a new specimen could be placed in its proper relations to those already fixed in the system and that would enable a student to find with certainty the name and place of any specimen that might fall into his hands, but each of these failed in some particulars to yield the desired result. Hence arose the mixed system of Werner, Hauy, Phillips and others, systems that still left much to be desired. Mohs the pupil and successor of Werner, earnestly believed that a natural system of mineralogy might be discovered as Linnaeus had done for botany. His intimate acquaintance with minerals, together with his ardor as a student of reform, enabled him to undertake such a work with as great a promise of success as could have fallen to any one, but the effort was too much for him.

The new nomenclature proposed by him, requiring as it did a complete change of names and terms previously used, overloaded a system which of itself failed to impress those interested in the subject with a confidence in its inherent worth. In like manner Berzelius made two distinct attempts to establish a system based purely on chemical principles, but his system never had the recognition he had looked for. The effort in each of the above cited instances, as well as in others of similar purpose and scope, while resulting in marked advancement in the status of the science, only made it more and more decidedly apparent that no system could meet with general acceptance that did not so combine chemical, crystallographic, optical and physical properties of minerals as to result in a fairly complete harmony and coincidence of the principles of each with those of the others.

It remained for the chemists and mineralogists of the last half of the eighteenth century to devote attention to a new question, the origin of minerals. In a review of the names of those who have secured eminence as contributors to the science of mineralogy, it will be noted that the majority of them are French or German in nationality. In like manner France and Germany have contributed to the solution of the question of the origin of minerals the greater part of effort and consequently have won the greater share of the honors.. It has required much patient devotion and skill to overcome the difficulties that thickly beset the path of progress in this as in other directions, but the results are highly gratifying, both in themselves and in the light they have let in upon the problem of classification of minerals. The key to the origin of minerals has been found in their artificial reproduction, using similar agents and like conditions, as in nature. Not more than half a dozen minerals remain that have not been artificially reproduced, so successful has been the work.

One result of this line of investigation has been a better delimitation of mineral families, even new members having been added by this process. By synthesis it has been discovered that many minerals, especially those of metamorphic origin, are never pure in nature, their exact composition not having been known until they had been artificially reproduced.

Geology has profited by this work also. For example the origin of granite had long baffled the geologists, but synthesis conclusively proved that granite could not be formed by purely igneous fusion, thus confirming the theory that it was of mixed origin. What the future has in store for the science of mineralogy it is impossible even to conjecture, but it would seem that its foundations at least have been broadly and securely laid.

In the consideration of my subject thus far, attention has been directed exclusively to the work accomplished in Europe. We now turn briefly to mineralogy in America. Practically no effort was made in this country along this line during the eighteenth century. Professor Silliman says that in 1803 it was a matter of extreme difficulty to obtain among ourselves even the names of the most common stones and minerals; and one might inquire earnestly and long before he could find any one to identify even quartz, feldspar, or hornblende among the simple minerals, or granits, porphyry, or trap among the rocks. There were at this time no text books, cabinets of minerals, or apparatus to aid or stimulate the latent interest of the people in this subject. In 1798 in New York the beginning of effort along this line was made by the organization of the American Mineralogical Society, of which Dr. Samuel Lathan Mitchell was the first president and the most active member. From this time interest and activity in the kindred sciences of chemistry and mineralogy grew with characteristic American spirit and enterprise. Chairs were established in the colleges and steps were taken to have these sciences taught in the higher schools. As a result of this activity a catalog of American minerals with their localities was published in 1825 by Dr. Samuel Robinson. This catalog contained over three hundred pages. Among the early promoters of this science, four stand forth with marked prominence, Dr. Archibald Bruce, Colonel George Gibbs, Professor Parker Cleaveland and Professor Benjamin Silliman.

Dr. Bruce, by the exchange of American specimens and by travel in Europe, during which he made the acquaintance of Hauy and others eminent in the science, gathered together an extensive cabinet of choice minerals, which with another collection made by Mr. B. D. Perkins was made readily accessible to the general public. They proved a remarkable stimulus to the popular interest in mineralogy. Dr. Bruce also established the American Journal of Mineralogy, the first purely scientific periodical in America. Tho of excellent character it met with the fate of many another worthy journalistic attempt thru lack of support. It may be stated here that Dr. Bruce gave in this journal a description of the Native Magnesia of Hoboken and of the Red Zinc Oxide of Sussex county, New Jersey, the first American species described by an American mineralogist. It is said that so well was his work done that these species remain today essentially as he described them, and that his papers are models of accuracy and form of statement.

Colonel Gibbs, a young man of considerable means, was an enthusiastic mineralogist and while in Europe made the most extensive and valuable collection of minerals ever brought to America, embracing more than twenty thousand specimens. Having found in Professor Silliman a zealous and sympathetic student in his favorite science, he proposed to install his cabinet at Yale College, if suitable accommodations were provided for it by the corporation. The proposition was promptly accepted, the cabinet was arranged under the personal supervision of its owner and it was then thrown open to the use of the college and the public. After fifteen years of free use of this collection, the college authorities purchased it for $20,000. It was a most profitable investment for the institution enabling it thus early to secure a prominence in mineralogy which under a distinguished line of mineralogists it has maintained ever since. Colonel Gibbs was also a very successful collector of minerals in this country, traveling widely for this purpose, freely gave of his time and knowledge to those interested in minerals, offered prizes to students making unusual attainments in the science, contributed important papers in scientific periodicals and in other ways proved a zealous promoter of interest in the study of mineralogy.

Hitherto little had been published in the English language that would serve as a text book for the schools. In England Kirwin's and Jameson's publications were either too old, or too much given to the defense of a particular phase of the subject, to be of value in securing a broad and up-to-date knowledge of the subject, but in 1816 Professor Parker Cleaveland of Bowdoin College published an Elementary Treatise on Mineralogy and Geology. It met with immediate general acceptance being of a high order of merit and receiving commendation even from the leading mineralogists of all Europe. Two editions were soon exhausted and a third was urgently called for, but unfortunately the author had been required to give his energies to the newly established Medical School at Brunswick and he could not respond to the demand, tho his lectures upon the subject were continued till his death which occurred in 1858. The feeling cannot be avoided that in his enforced withdrawal from a more exclusive devotion to the subject, mineralogy in America lost a masterly champion.

The good fortune of Yale in securing the very superior cabinet of Colonel Gibbs has already been noted. But as cabinets, any more than buildings and equipments, do not make a great school of themselves, Yale's good fortune would have availed but little without the directing and vitalizing powers and activities of a young man upon her faculty at that time, Professor Benjamin Silliman, who was one of the earliest to take up the subject of Mineralogy with zeal and determination. Four years previous to the first opening of the Gibbs cabinets at New Haven he had secured for the institution the second best collection of minerals in the country, namely that of Mr. B. D. Perkins of New York. The reputation in mineralogy thus early secured by Yale and steadfastly maintained ever since, affords the best evidence of the wisdom on the part of an institution of securing the best obtainable in equipment and in men. The best is none too good.

Professor Silliman was instrumental in the establishment of the American Journal of Science in 1818. It was at once very helpful to all branches of science, but especially so to Mineralogy, to which special attention was given in all the earlier volumes. For more than fifty years he held the chair of Chemistry, Mineralogy and Geology, and when by reason of advancing years, he gave up the work, he had the pleasure of entrusting the two last named to the hands of James D. Dana who proved a worthy successor, as is abundantly evidenced by the fruits of his labors, both as teacher and author. His Geologies and Mineralogies long held the foremost place among American publications of their kind as authoritative exponents of the practical value and status of these two sciences. Since his retirement the chair of Mineralogy has been occupied by Professor George J. Brush and Samuel L. Penfield who have well maintained the high standard set by their distinguished predecessors.

The scope and intent of this paper forbids even the mention of many others who have gained a name and reputation as efficient promoters of the science of Mineralogy in America. At the risk of its seeming inappropriate in a gathering not distinctively pedagogical in its character, I cannot close, without making an earnest, tho brief, plea for a more general interest in the dissemination of at least a fair working knowledge of the commoner minerals and rocks. While mineralogy, perhaps, is receiving its share of consideration at the hands of investigators and of those who are carrying their studies into the advanced stages of the subject, popular interest in the common minerals and rocks is not as deep or general as it is in any of the other lines of science, unless it be astronomy. The same arguments that are made for a wider dissemination of knowledge of the facts and principals of the other sciences apply with equal, if not greater, force to mineralogy. Just as every one should be acquainted with the names and characteristics of the trees about him, so should he be familiar with the minerals likely to be met with any day and that enter into the make-up of the rocks of common occurrence and give to the soils their essential qualities. The idea is quite prevalent that an understanding of chemistry is essential to the acquirement of a practical knowledge of mineralogy. This is not so, of course. While chemistry is contributory to a full knowledge of minerals, they can be determined and known in a practical way by a study of their external qualities mainly, or wholly, and it is for such a study of them in our secondary schools at least that I would here enter my plea. The disciplinary results of such a study are especially to be commended as bearing most effectively upon the development not only of the observing faculties, but also in a still higher degree of the power of reflection and judgment.

I know of no branch of science in which a single term of well directed effort will result in more practical good both in training and knowledge than from the determination of minerals from a consideration of their external qualities mainly. Along with and included in this should go, of course, the recognition of the mineral constituents of the granites and other common rocks. Thereafter, with a well trained muscular sense in judging of weight and with no more apparatus than a knife-blade and a piece of glass for testing hardness, one, while in the field, may recognize with a fair degree of certainty a large percent of the minerals and rocks studied. Later with recourse to a bottle of acid for testing carbonates, a small magnet, an inexpensive balance for a more exact determination of specific gravity and a simple blow-pipe, all doubt may be removed respecting any of those that had been identified only tentatively and the most, if not all, of those too difficult for recognition in the field may thus be determined with assurance. The Mineralogy of today is established upon a well defined basis, occupies an important place among kindred sciences and should receive at the hands of educators a more universal recognition in the courses of secondary schools and colleges.